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A high-fidelity approach towards heat transfer prediction of pool boiling MIAD YAZDANI, ABBAS ALAHYARI, THOMAS RADCLIFF, United Technologies Research Center — A novel numerical approach is developed to simulate the multiscale problem of pool-boiling phase change with an unprecedented fidelity and cost. The particular focus is to predict the heat transfer coefficient of pool-boiling regime and its transition to critical heat flux on surfaces of arbitrary shape and roughness distribution. The large-scale of the phase change and bubble dynamics is addressed through employing off-the-shelf methods for interface tracking and interphase mass and energy transfer. The small-scale of the microlayer which forms at early stage of bubble nucleation is resolved through asymptotic approximation of the thin-film theory which provides a closed-form solution for the distribution of the micro-layer and its influence on the evaporation process. In addition, the surface roughness and its role in bubble nucleation and growth is represented based on thermodynamics of nucleation process which allows the simulation of pool boiling on any surface with known roughness and enhancement characteristics. The numerical model is validated for dynamics and hydrothermal characteristics of a single nucleated bubble on a flat surface against available literature data. In addition, the model's prediction of pool-boiling heat transfer coefficient is verified against reputable correlations for various roughness distributions and different surface alignment. Finally, the model is employed to demonstrate pool-boiling phenomenon on enhanced structures with reentrance cavities and to explore the effect of enhancement features on thermal and hydrodynamic characteristics of these surfaces.

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